Toward Operational Ecosystem Modeling to Support Adaptive Management in the Great Lakes

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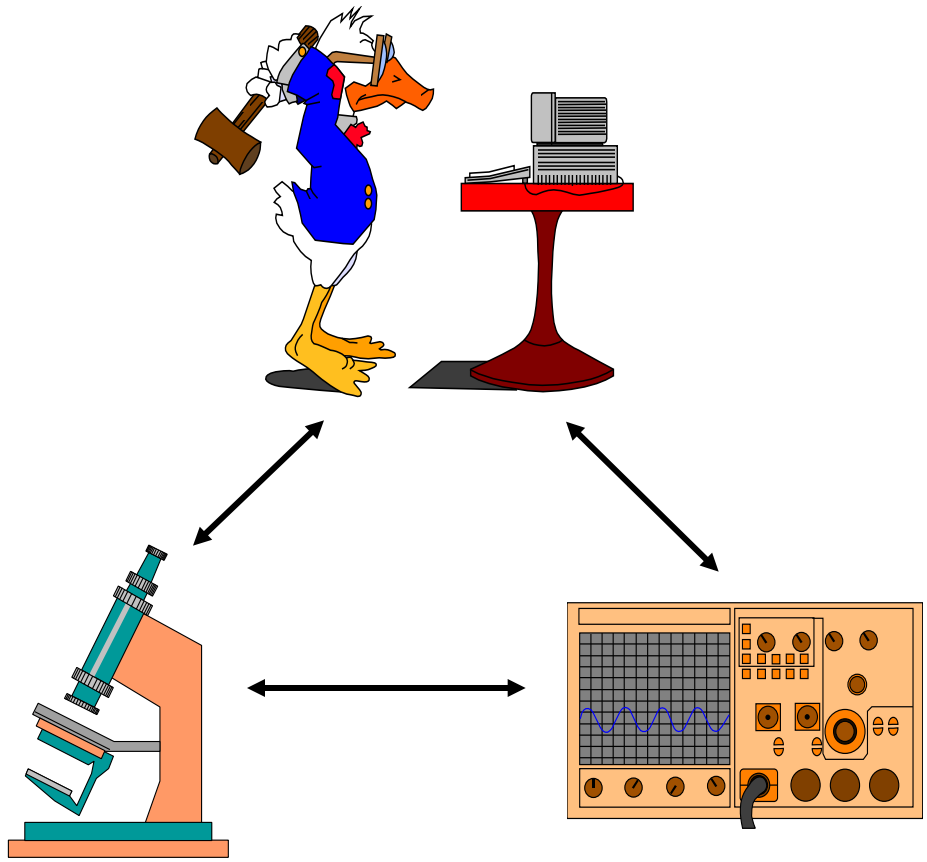
Water Environment | Scientists Engineers

Premise

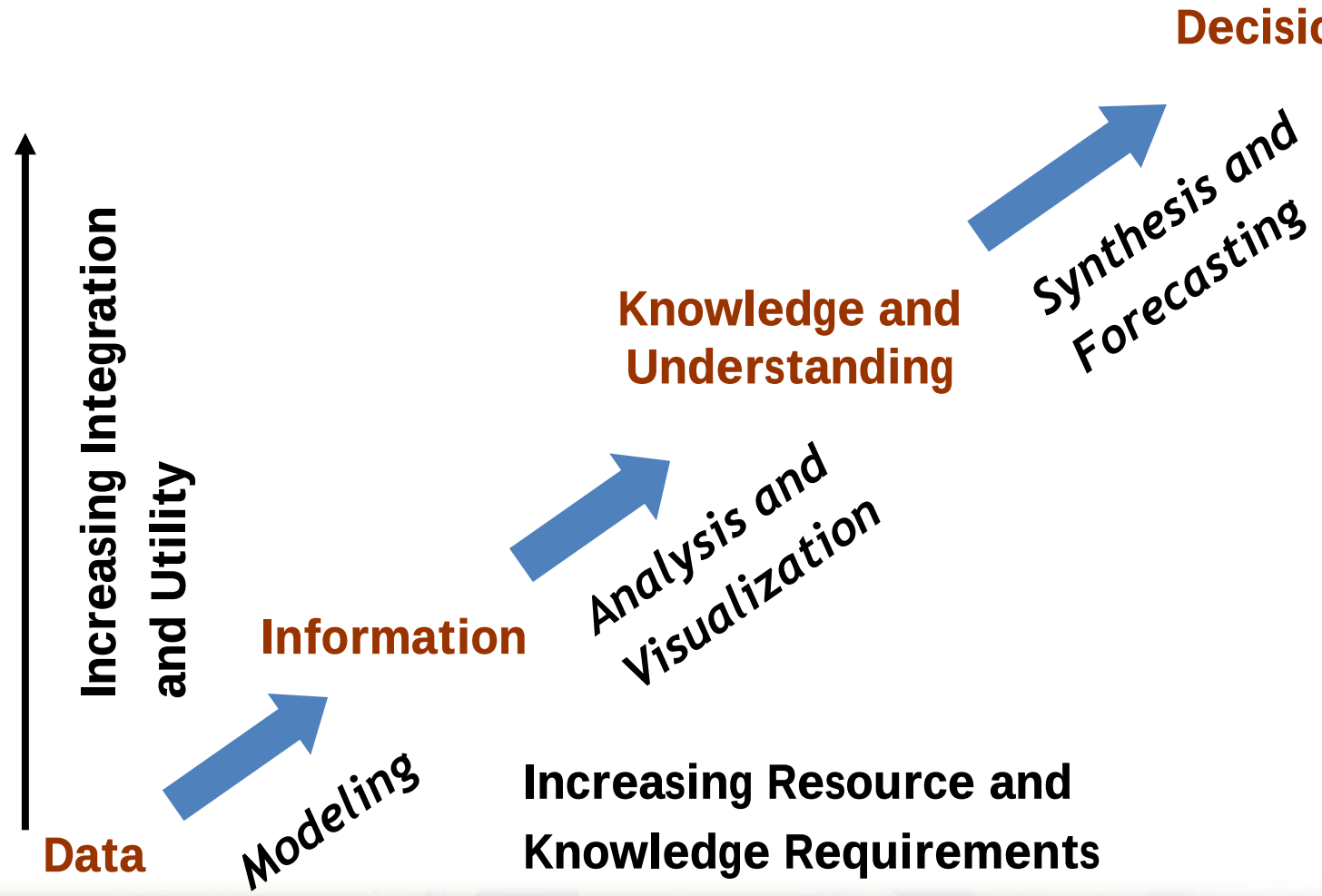
- Great Lakes present complex environmental challenges in large coastal ecosystems
- Model simulations have become increasingly essential
  - Assess what happened?
  - Why it happened?
  - What will/could happen?
- Scenario-type ecological forecasts are critical toward for enabling decision makers to transition from reactive to adaptively proactive
  - Great Lakes community has been using models for long time (e.g., Fisheries and Nutrient Management Models)…but this development has been piecemeal
  - Need to run these ecosystem models in an operational mode

Great Lakes Research/Management Philosophy – Coordinated Whole System Studies

- Models provide insight and make projections
- Research provides Understanding and parameterization for Model Development
- Monitoring provides input and credibility for Models

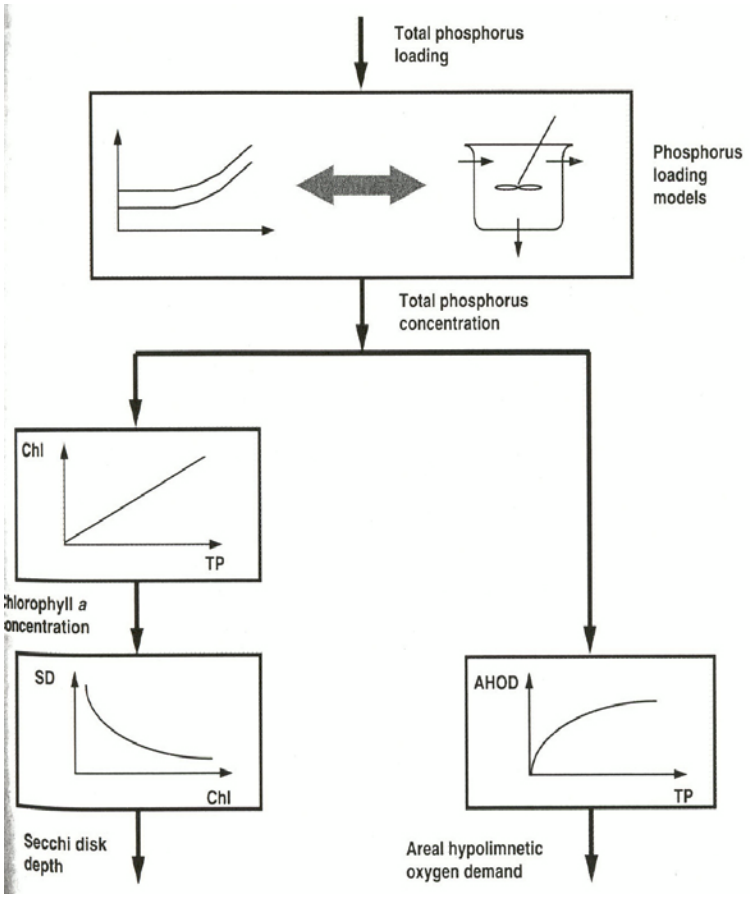


Integrated Decision Support Modeling: Converting Data to a Decision



Task Group III used Ensemble Modeling to establish Annex 3 target P loads

- Vollenweider (all basins)
  - Empirical
  - Steady-state
- Chapra (all basins)
  - Semi-empirical
  - Dynamic TP mass balance
  - Chlorophyll *a* and DO empirically correlated with TP
- Thomann Lake I model (Lake Ontario and Lake Huron)
  - Process model
  - Dynamic MB of P, N, chlorophyll, zooplankton
- DiToro Lake Erie model
  - Process model
  - Dynamic MB of P, N, Si, DO, diatom and non-diatom chlorophyll, zooplankton
- Bierman Saginaw Bay model
  - Process model
  - Dynamic MB of P, N, Si, five phytoplankton groups, zooplankton

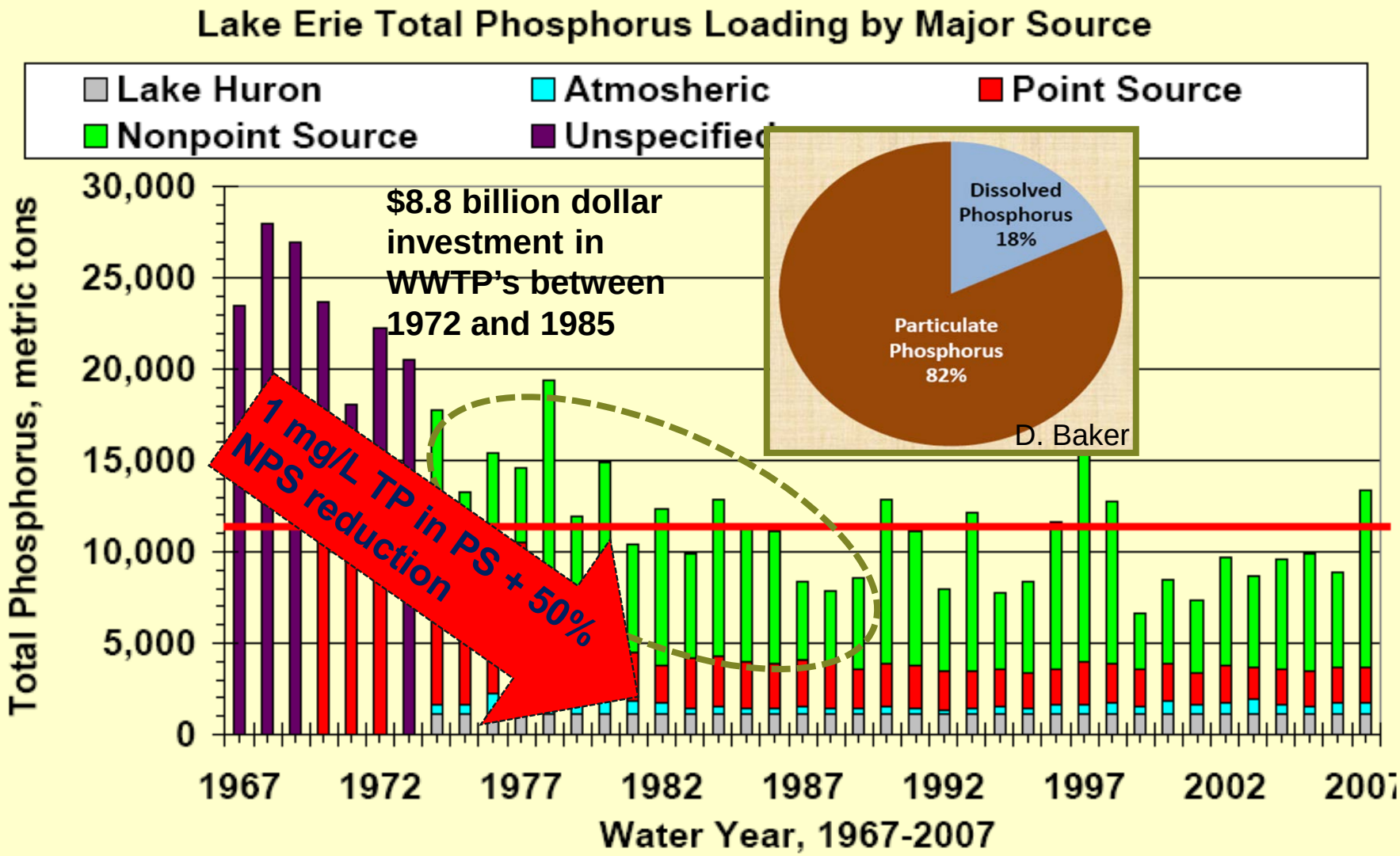


Target Phosphorus Loads (metric tonnes/yr)

Basin	1976 TP Load (mta)	Target TP Load (mta)
Lake Superior	3600	3400
Lake Michigan	6700	5600
Main Lake Huron	3000	2800
Georgian Bay (LH)	630	600
North Channel (LH)	550	520
Saginaw Bay (LH)	870	440
Lake Erie	20000	11000*
Lake Ontario	11000	7000*

* Require 1 mg/L PS effluent + 50% diffuse source reduction or
0.5 mg/L PS effluent + 30% diffuse source reduction

An overview of phosphorus loading to Lake Erie



Data from Rockwell and Dolan

Lake Erie Model Post-audit (Chl *a*)

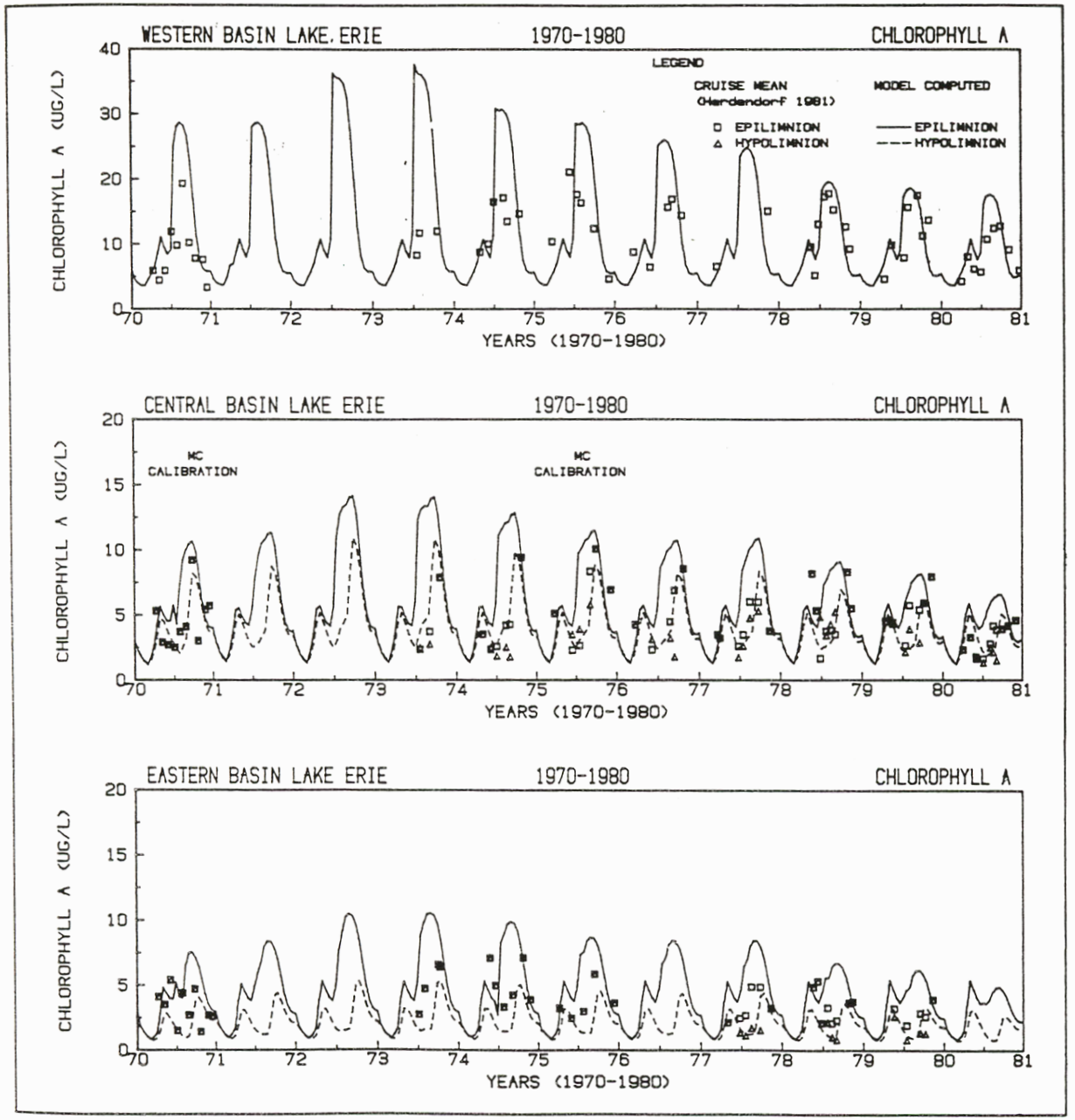


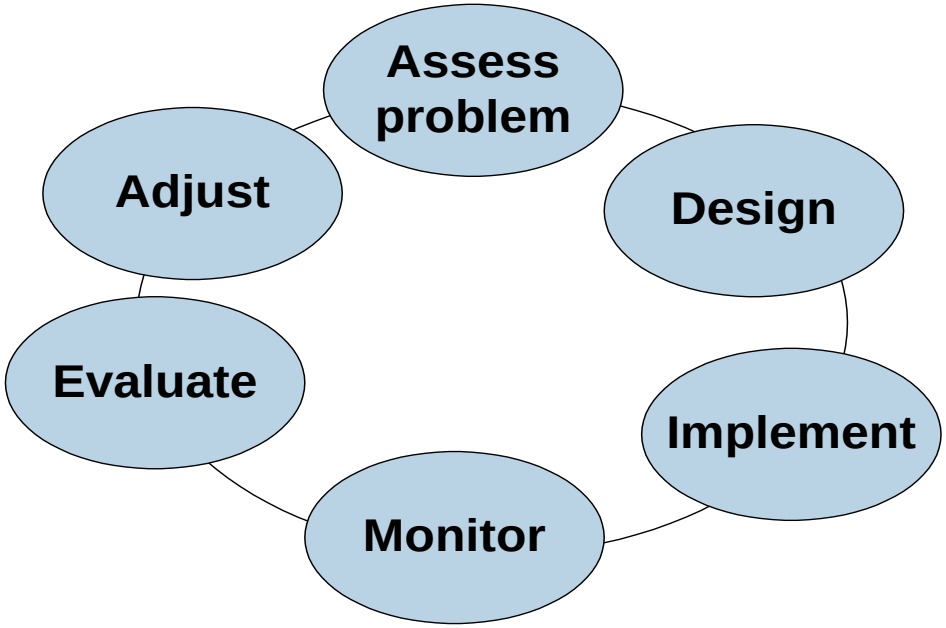
FIG. 10a. Comparison of model predicted and 1970 to 1980 observed cruise mean chlorophyll a *— western, central, and eastern basins of Lake Erie.*

Late 1990s Saw Re-occurrence of HABs and Nuisance Benthic Algae

Microcystis **blooms in bays and shallow basins**

Nuisance benthic algae (*Cladophora and Lyngbya wollei)* blooms in nearshore washes up on shorelines

GLWQA 2012 Protocol calls for application of Adaptive Management in dealing with nearshore management issues.



Conventional Adaptive Management Approach

"The Parties shall be guided by the following principles and approaches in order to achieve the purpose of this Agreement: …

(b) adaptive management – implementing a systematic process by which the Parties assess effectiveness of actions and adjust future actions to achieve the objectives of this Agreement, as outcomes and ecosystem processes become better understood;"

Adaptive Management Approach using Operational Ecosystem Modeling

Example using Saginaw Bay nutrient – eutrophication problem

The Saginaw Bay Problem

- Issues
  - Re-occurrence of Harmful Algal Blooms (*Microcystis*)
  - Nuisance benthic algae and "muck" on shoreline
- Potential Causes…
  - Dreissenid invasion
    - impacts on light, plankton production, and phosphorus cycling
  - Phosphorus loading
    - Non-point source loads
    - Phosphorus bioavailability
- The Solution…
  - Control phosphorus loads, but how much…
  - Need to understand ecosystem responses to P load reductions
- Adaptively evaluate alternative management actions using an *Operational Ecosystem Model*…
  - SAGEM2 developed as part of the NOAA Saginaw Bay multi-stressor project

SAGEM2 connects stressors to ecological responses

Loads and Forcing Functions

Nutrient loads

Solids loads

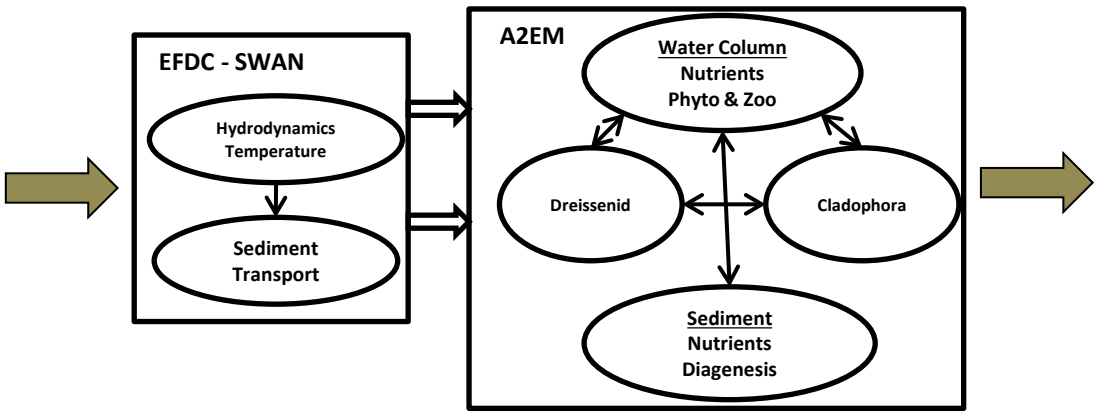
Hydrology and Water levels

Dreissenids

Temperature

Wind

SAGEM2



Ecological Responses

Nutrient concentrations /budgets

HABs (Microcystis)

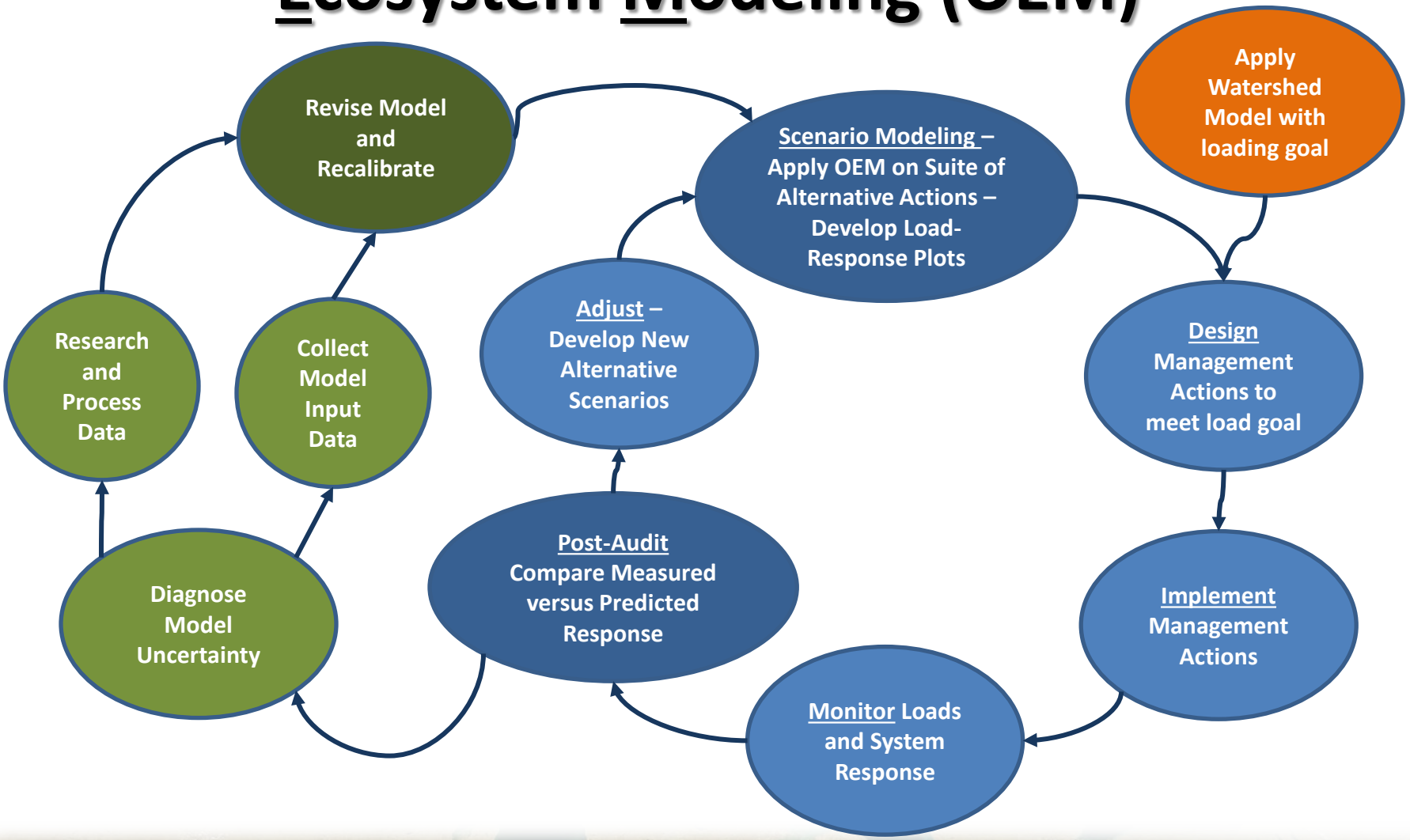
Benthic algae (Cladophora) and potential "muck" distribution

Total chlorophyll a

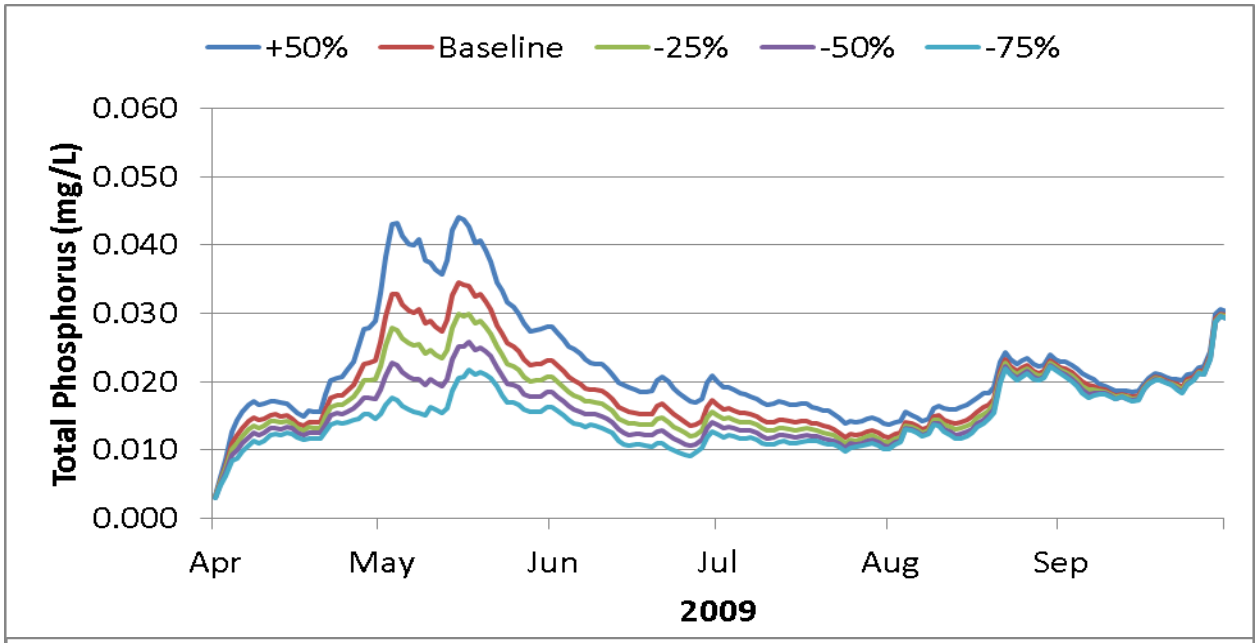
Dissolved Oxygen

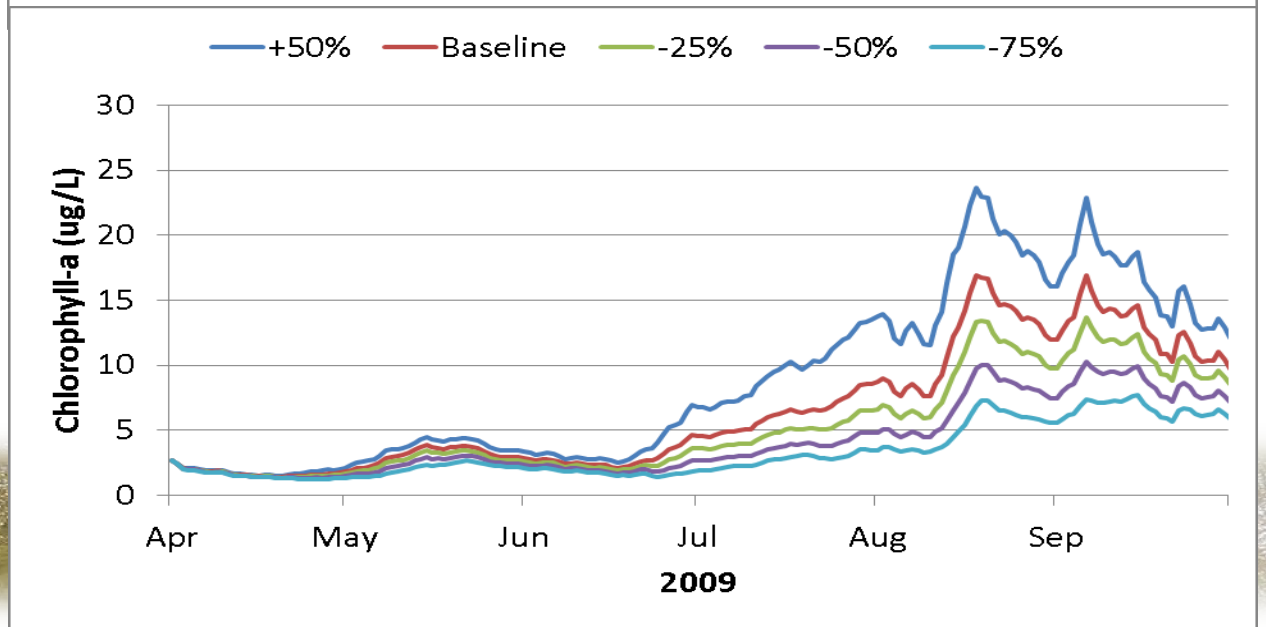
Carrying capacity for fish

Adaptive Management using Operational Ecosystem Modeling (OEM)

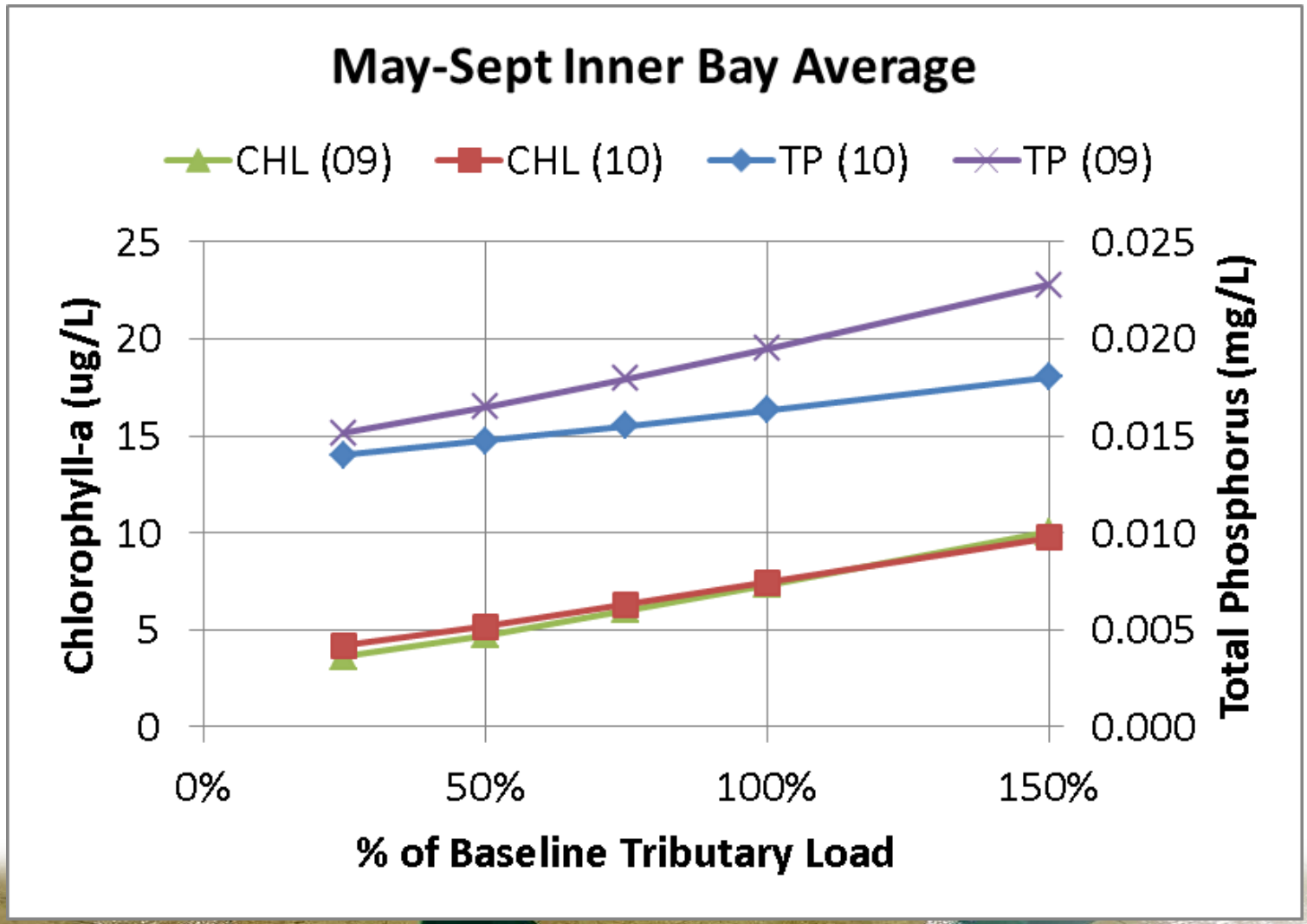


TP and Chlorophyll a Response to P Load Changes – 2009

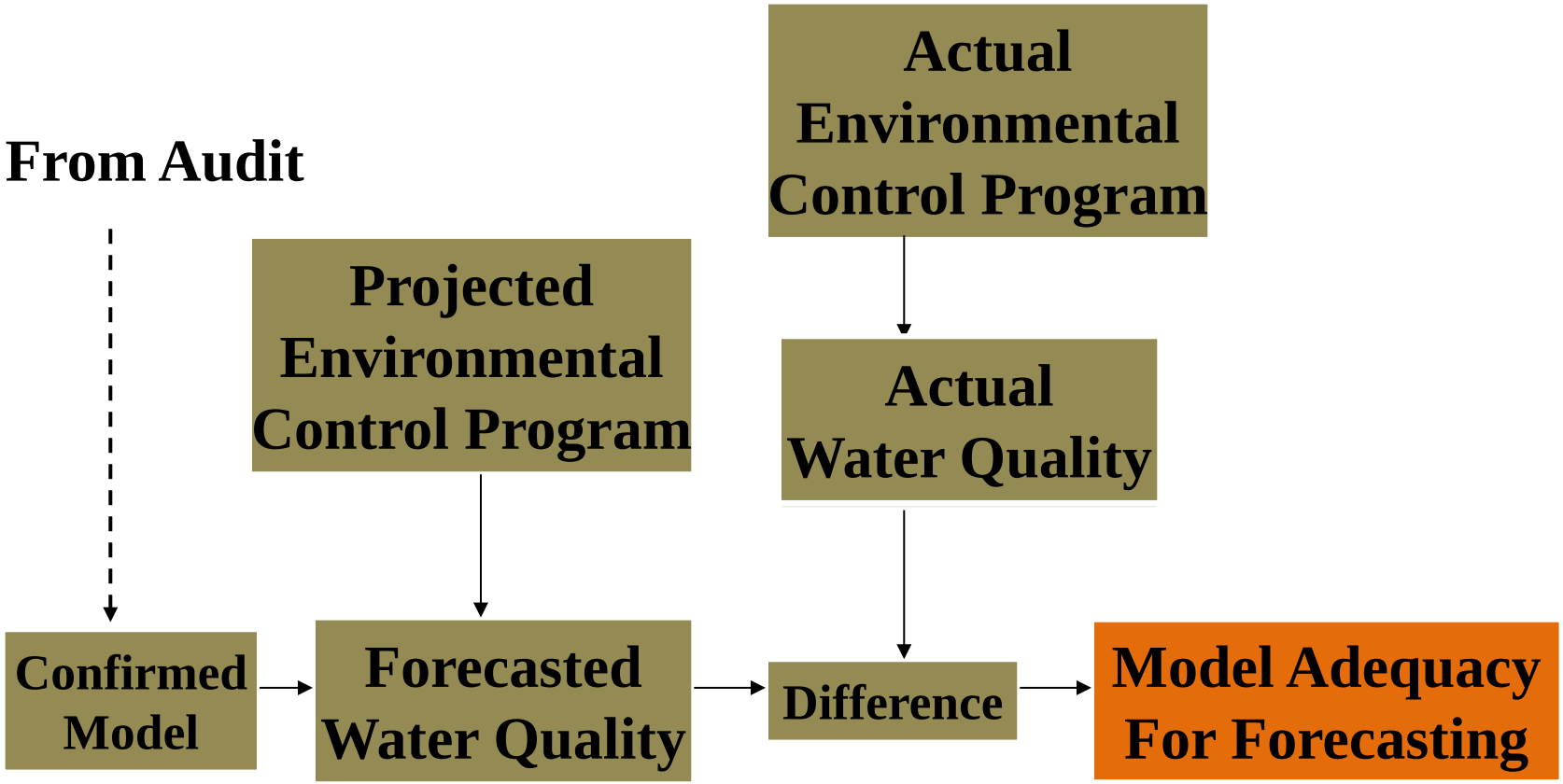




Inner Bay Summer Average Response to Tributary P Load Reductions



Post-audit of OEM



Steps to Develop an OEM

1. Select, formulate, and/or revise model to support:
   - User needs and management questions
   - System characteristics
   - Programmatic constraints
   - Desired level of model uncertainty – leads to adaptive improvement cycles
2. Collect calibration/confirmation data sets and perform the process
3. Develop model operation plan
   - Routine data needs and model application process
   - Output analysis and visualization
   - Delivery of model results to user and user support
   - Adaptive model refinement plan
   - Plan for data and model output storage and archiving
4. Develop institutional home for model and funding plan for model operation

Opportunities for Great Lakes Operational Ecosystem Modeling

- Nutrient – Eutrophication management
- Nearshore – offshore production gradients
- Beach contamination forecast models
- Chemical of emerging/mutual concern – multi-media and climate change
- Water levels and flows regulation – climate change
- Fishery management
- Regional sediment management – dredging and dredge disposal
- AOC delisting and ongoing management

Current Operational Model Initiatives

- NOAA Great Lakes Forecasting System ongoing operational modeling
- IUGLS water level adaptive management workgroup
- Lake Michigan working group to develop a community modeling and forecasting framework for the LaMP
- NOAA-CSCOR project: Feasibility Study for operational regional coastal ecosystem management models
  - Beth Turner – Project Officer
  - Team – Jim Fitzpatrick, Damian Brady, Joe DePinto, Dom DiToro, Mike Kemp, Don Scavia
  - DePinto responsible for Great Lakes region

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